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Simulation of Man's Respiratory and Metabolic Functions by the Automated Breathing Metabolic Simulator

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8766

Simulation of Man's Respiratory and Metabolic Functions by the Automated Breathing Metabolic Simulator

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UNITED STATES DEPARTMENT OF THE INTERIOR
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SIMULATION OF MAN'S RESPIRATORY AND METABOLIC FUNCTIONS BY THE AUTOMATED BREATHING METABOLIC SIMULATOR

by

Maria I. DeRosa [1] and Roy Levin [2]

ABSTRACT

This Bureau of Mines report describes the Automated Breathing Metabolic Simulator and its hardware and software systems with emphasis on the role exerted by the software program subroutines in controlling the hardware mechanisms during the simulation of man's respiratory and metabolic functions.

INTRODUCTION

The Automated Breathing Metabolic Simulator (ABMS), designed and fabricated by IBM Corp.[3] for the Dust Control and Life Support Group at the Pittsburgh Mining and Safety Research Center of the Federal Bureau of Mines, is a mechanical man which simulates man's respiratory and metabolic functions during a sequence of assorted work tasks. For each work task, the breathing rate, breathing depth, energy expenditure, functional residual capacity (amount of air remaining in the lungs at the end of expiration), and breathing waveform are simulated. While man testing is required to assess the subjective performance of a breathing apparatus, the ABMS (fig. 1) allows the researcher to examine at length the performance of the breathing apparatus under a sequence of controlled test conditions.

This report provides a brief description of the ABMS hardware and software systems, with special attention to the method by which the software program subroutines control the hardware mechanisms during the simulation of man's respiratory and metabolic functions.

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FIGURE 1. - Automated Breathing Metabolic Simulator (ABMS).

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HARDWARE SUBSYSTEM

The ABMS hardware (fig. 2) basically consists of a bellows, an oxidation chamber, and a temperature and humidity conditioner.

Man's breathing function is simulated by the bellows, which draws air from the breathing apparatus through the artificial trachea and pumps expired air back to the apparatus. The periodic motion of the bellows is controlled by a drive motor operating a crankshaft and connecting rod. The motion of the connecting rod is transmitted to the bellows by means of a lever operating on a movable fulcrum. The fulcrum position along the lever arm is controlled by

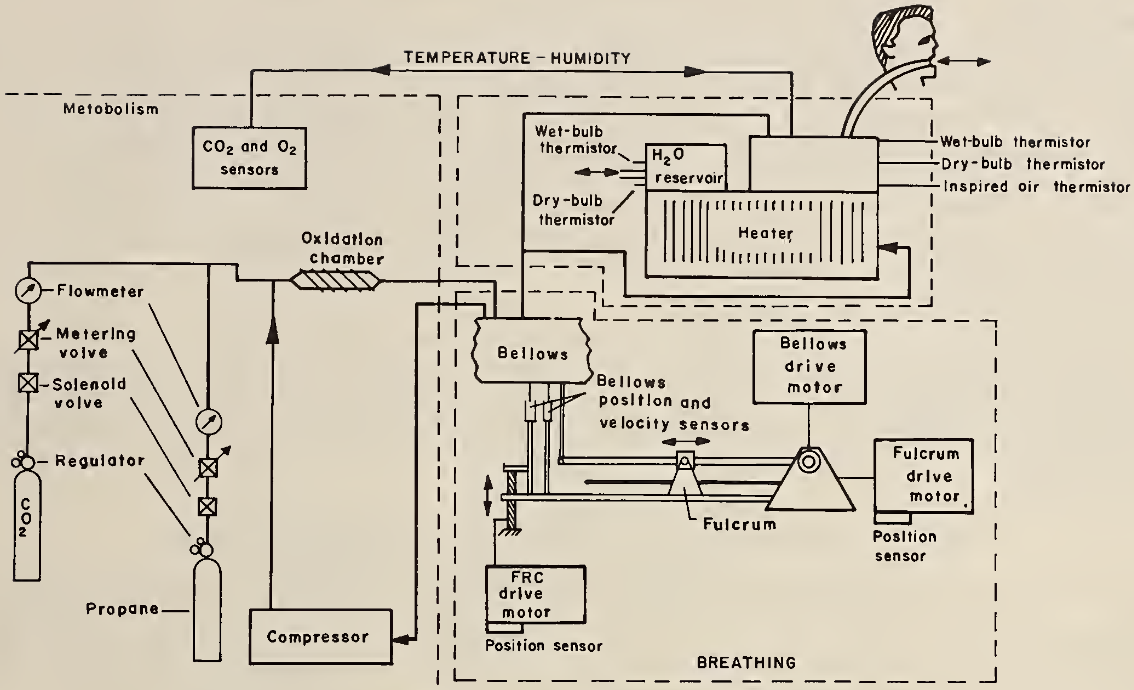

FIGURE 2. - Schematic diagram of ABMS hardware system.

a drive motor and is used to control the breathing depth. The functional residual capacity (FRC) is controlled by a separate drive motor.

Man's metabolism is simulated by controlling the CO_2-to-O_2 ratio in the expired air. This is accomplished by drawing the inspired air from the top of the bellows into the oxidation chamber, where propane is added to burn the oxygen and to produce carbon dioxide. The CO_2 produced during combustion is insufficient to simulate man's metabolism, and a precalculated amount of CO_2 is added to the oxidation chamber. The propane and CO_2 flows are controlled by metering valves. The burned air, after being cooled, is returned to the top of the bellows. The mixture in the bellows then is passed through a temperature-humidity chamber, where it is warmed to body temperature (98.6°) and humidified to 100% humidity, and then is passed back to the respiratory device.

The hardware mechanisms that are responsible for the simulation of man's respiratory and metabolic parameters thus are the three drive motors (bellows, fulcrum, and FRC) and the two propane and CO_2 flow-metering valves, plus sensors for software use.

COMPUTER SOFTWARE PROGRAM

The computer software program involves 73 subroutines; 18 exert direct control over the hardware, and the other 55 perform ancillary programing tasks. The appendix groups the various subroutines into functional areas. The program is written in assembly language and essentially occupies the total

storage (12,000 words) of the Programable Data Processor--11 Computer[4] used with the present ABMS.

Physiological data for the 5, 50, and 95 percentile man[5] for six work tasks are permanently stored in the STANDARD STATES TABLES (STA. STA. TAB.) of the software program, which are available for consultation at the Pittsburgh Mining and Safety Research Center. These data are used for the simulation, and if requested are displayed on the teleprinter during the actual simulation. The work tasks stored are rest, walk (3 mph), run (6 mph), overcast (carrying 50 pounds of weight for 10 feet to a small passageway and then crawling to the bottom of the ramp), pulley (raising 45 pounds of weight to a height of 5 feet), and laddermill (climbing a laddermill moving at 1 vertical foot per second).

The physiological data stored for each work task are breathing rate (breaths per minute), breathing depth (liters per breath), energy expenditure (British thermal units per hour), functional residual capacity (liters), and respiratory exchange ratio (CO_2/O_2) (table 1). The breathing waveforms, grouped into heavy, medium, and rest waveforms according to the work task (fig. 3), have also been stored in the STA. STA. TAB.

TABLE 1. - Physiological data for six work tasks stored in the ABMS software program

Work task and percentile man	Breathing rate, breaths per minute	Breathing depth, liters per breath	Energy expenditure, Btu/hr	Functional residual capacity, liters	Respiratory quotient (CO_2/O_2 ratio)
Rest:					
5............	7	0.716	248	2.119	0.86
50............	15	.716	316	2.400	.86
95............	24	.716	383	2.718	.86
Walk:					
5............	13	1.21	1,161	2.119	.94
50............	24	1.21	1,476	2.400	.94
95............	35	1.21	1,790	2.718	.94
Run:					
5............	28	2.32	2,793	2.119	1.13
50............	35	2.32	3,551	2.400	1.13
95............	42	2.32	4,308	2.718	1.13
Overcast:					
5............	17	1.30	1,075	2.119	.92
50............	23	1.30	1,370	2.400	.92
95............	30	1.30	1,662	2.718	.92
Pulley:					
5............	18	1.13	1,293	2.119	1.07
50............	18	1.78	1,651	2.400	1.07
95............	18	2.43	2,003	2.718	1.07
Laddermill:					
5............	27	2.32	2,900	2.119	1.00
50............	35	2.32	3,480	2.400	1.00
95............	41	2.32	4,060	2.718	1.00

[4]Reference to specific equipment (or trade name or manufacturer) does not imply endorsement by the Bureau of Mines.

[5] 5 percentile man = mean - 1.65 · standard deviation.
50 percentile man = mean.
95 percentile man = mean - 1.65 · standard deviation.

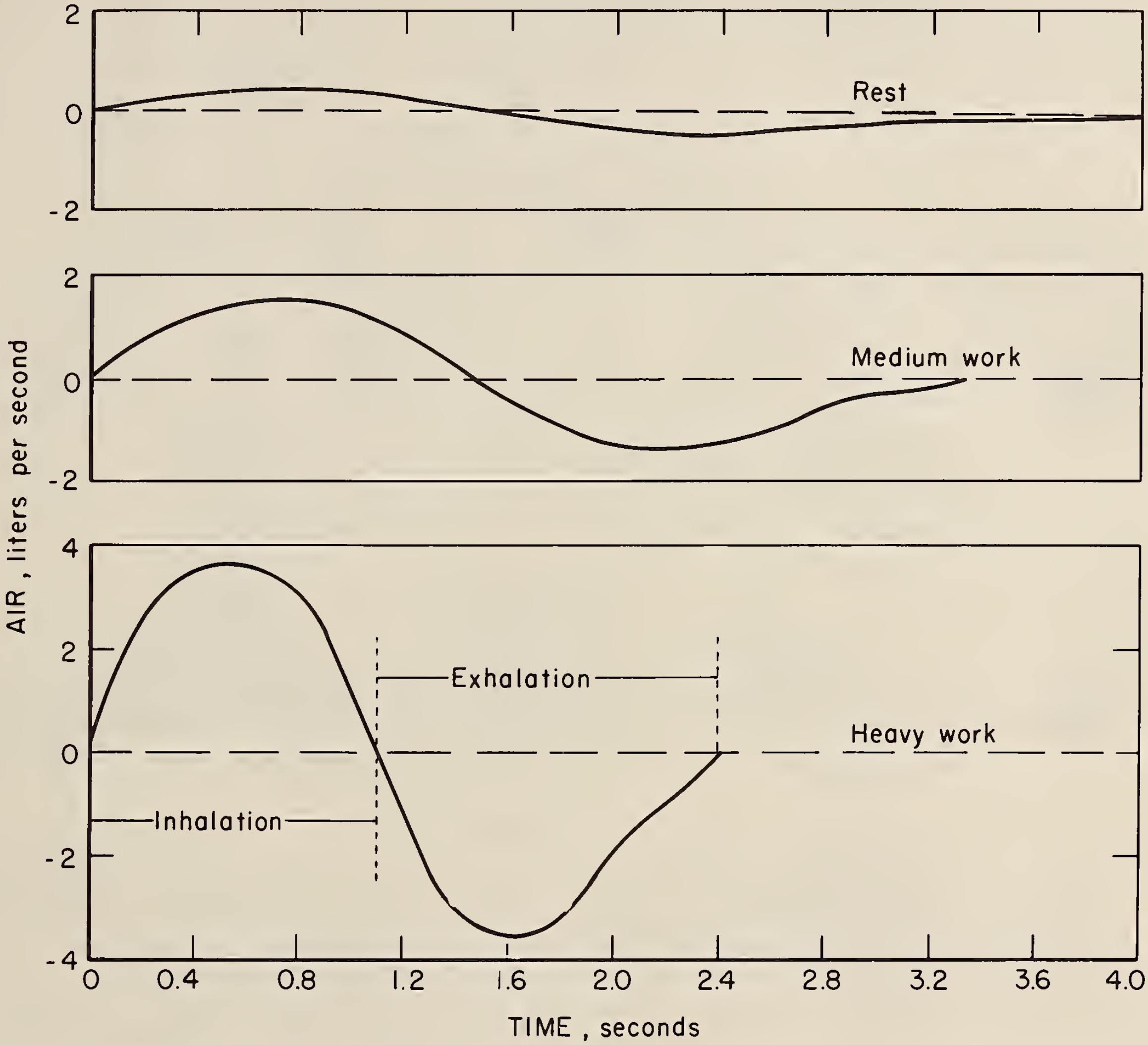

FIGURE 3. - Breathing waveforms for rest, medium work (pulley, overcast), and heavy work (running, climbing).

The software program conducts three basic operations:

1. It converts the programed respiratory and metabolic values into hardware mechanism positions.

2. It positions, controls, and monitors those hardware components.

3. It controls the transition from one work task to a new work task.

The first two operations are performed during the simulation of steady-state work tasks (fig. 4). The third operation is performed during the transition of one work task to another (fig. 5).

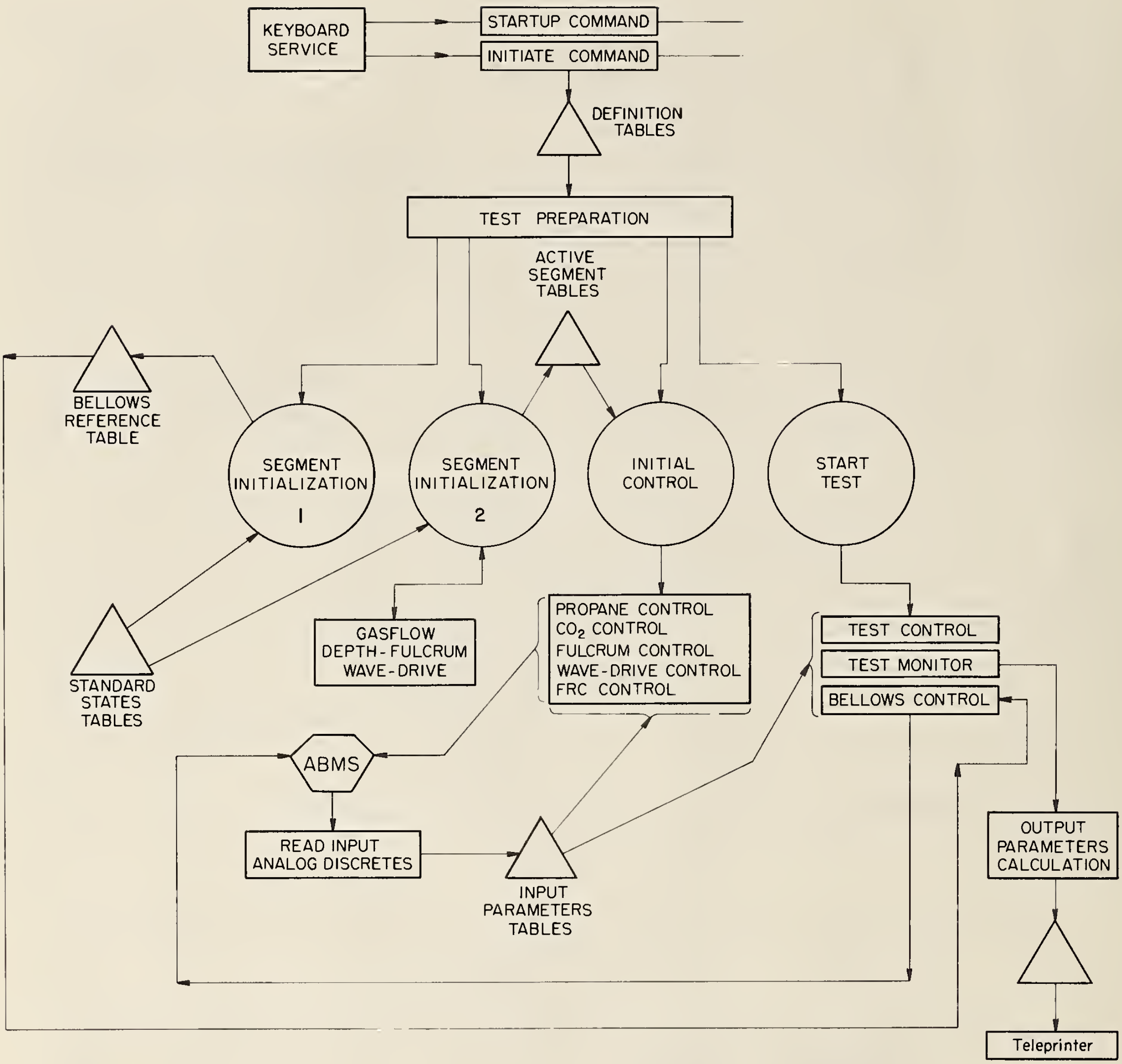

FIGURE 4. - Schematic diagram of ABMS software program subroutines during the simulation of a steady-state work task.

A test run is initiated by a query and response via the KEYBOARD SERVICE routines. The user introduces the number and kind of work tasks and the type of printout desired.[6] INITIATE COMMAND stores the information in the DEFINITION TABLES. At the same time, the STARTUP COMMAND starts the bellows at a nominal speed and turns on the heater in the oxidation chamber. When the chamber temperature is at the ignition level, the simulator is ready for test

[6] International Business Machines Corp., Federal System Division (Gaithersburg, Md.). Automated Breathing Metabolic Simulator Operation Manual. BuMines Contract H0112209, January 1973, pp. 1-35.

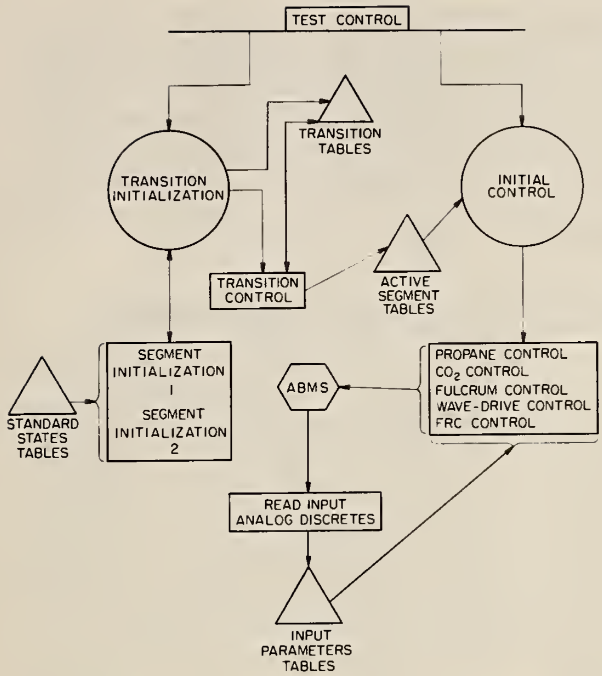

FIGURE 5. - Schematic diagram of ABMS software program subroutines during the transition of one work task to another.

operations, and TEST PREPARATION is called. This subroutine is responsible for initiating most of the processes through which physiological parameters are converted into hardware mechanism positions.

Converting Operation

TEST PREPARATION uses the SEGMENT INITIALIZATION 1 (SEGIN 1) to obtain the breathing waveform for the breathing cycle of the work task being simulated. The data stored in the STA. STA. TAB. are precalculated from the breathing rate and breathing depth values; the breathing rate determines the time necessary to accomplish a breathing cycle, and the breathing depth determines the amplitude of the cycle.

The points through which the breathing waveform will be fitted correspond to the positions to be maintained by the bellows during each breathing cycle. These positions are transmitted by SEGIN 1 to the BELLOWS REFERENCE TABLE (BELREF) and used by the BELLOWS CONTROL (BELCTL) during the monitoring functions.

The SEGMENT INITIALIZATION 2 (SEGIN 2) then is called by TEST PREPARATION to convert the energy expenditure, breathing rate, breathing depth, and FRC into O_2 consumption and hardware positions. SEGIN 2 uses GASFLOW, DEPTH-FULCRUM, and WAVE-DRIVE subroutines to perform the actual conversion. GASFLOW converts the energy expenditure into O_2 consumption and computes the amount of propane to be added to the combustion chamber from the O_2 consumption value, 1 volume of propane for 5 volumes of O_2 (table 2). GASFLOW also computes the CO_2 value derived from the combustion (table 2); an additional precalculated value of CO_2, which depends on the work task, is obtained by GASFLOW from the

STA. STA. TAB. and added to the combustion chamber to meet the total CO_2 required for the desired CO_2-to-O_2 ratio. The propane and CO_2 values so computed are used to control the ABMS hardware flowmetering valves, which supply propane and CO_2 to the combustion chamber. The DEPTH-FULCRUM subroutine converts the breathing depth value into fulcrum and FRC drive motor positions, and finally the WAVE-DRIVE subroutine converts the breathing rate into bellows drive motor voltages. All of the computed respiratory and metabolic parameter values are transmitted by SEGIN 2 to the ACTIVE SEGMENT TABLES (ACTAB).

TABLE 2. - Metabolic data as computed by the ABMS software program

Work task and percentile man	Oxygen consumption, l/min	Propane flow, cm^3/min	CO_2 flow, cm^3/min	CO_2 in expired breath,[1] pct	O_2 in expired breath,[1] pct
Rest:					
5..............	0.214	40	55	3.7	16.7
50..............	.273	55	75	2.2	18.5
95..............	.331	67	94	1.65	19.1
Walk:					
5..............	1.001	200	326	5.9	14.7
50..............	1.273	255	661	4.9	16.7
95..............	1.543	310	542	3.45	17.4
Run:					
5..............	2.408	480	1,290	4.2	17.3
50..............	3.061	605	1,610	4.25	17.3
95..............	3.714	740	1,990	4.34	17.2
Overcast:					
5..............	.927	185	279	3.8	16.8
50..............	1.181	235	366	3.6	17.1
95..............	1.433	287	466	3.4	17.4
Pulley:					
5..............	1.115	225	455	5.6	15.5
50..............	1.423	285	654	4.7	16.6
95..............	1.727	345	808	4.2	17.1
Laddermill:					
5..............	2.500	500	1,004	4.0	17.0
50..............	3.000	600	1,197	3.7	17.3
95..............	3.500	700	1,396	3.68	17.3

[1]Data extrapolated by the authors.

Positioning Operation

As soon as the conversion process has terminated, TEST PREPARATION calls INITIAL CONTROL to position the hardware to the expected values spelled out in ACTAB; during this time no output is transmitted to the teleprinter. INITIAL CONTROL uses the PROPANE, CO_2, FULCRUM, FRC, and WAVE-DRIVE CONTROL subroutines to adjust the propane and CO_2 flow valves and the bellows, fulcrum, and FRC drive motors, according to the stipulated values. At the same time these controlling subroutines set up a comparison process between the expected positions stored in ACTAB and the actual readings for those positions transmitted

by the ABMS hardware through the READ-INPUT-ANALOG-DISCRETES subroutine (RIAD). The readings are stored in the INPUT PARAMETER TABLES (INPAR). If the readings transmitted by RIAD are not within predefined tolerances of the expected values from ACTAB, a command is sent to the respective hardware valves (propane and CO_2) and/or drive motors (bellows, fulcrum, and FRC) to adjust their positions to the values spelled out in ACTAB.

Monitoring Operation

While the foregoing processes are being carried out, TEST PREPARATION has also called START TEST to monitor other aspects of the hardware. Specifically, START TEST uses BELLOWS CONTROL to sample the bellows positions every 50 msec and adjusts the bellows positions to the positions prestored in BELREF. The positions are stored by COLSAM and used by the WAVEFORM OUTPUT (PLOT), if requested as one of the teleprinter outputs. Concurrently, TEST MONITOR is called to examine the oxidation chamber. If any safety switches are open, or if the chamber temperature is above the warning level, CHECK and/or HIGH CHAMBER TEMPERATURE are called to terminate the test. If the test is proceeding correctly, the hardware readings, transmitted by RIAD, will be computed and converted to user's language by the OUTPUT PARAMETER CALCULATION (OPCAL). In particular, OPCAL computes the current values for--

1. Inhaled air temperature.
2. Wet-bulb temperature.
3. Relative humidity.
4. CO_2 percent in the inspired and expired air.
5. O_2 percent in the inspired and expired air.
6. CO_2 partial pressure.
7. Propane flow.
8. CO_2 flow.
9. O_2 consumed.
10. British thermal units per hour.
11. Respiratory exchange ratio (CO_2/O_2).
12. FRC.
13. Depth of breath.
14. Oxidation chamber temperature.
15. Breathing rate.

16. Inspired air pressure.

17. Expired air pressure.

These quantities are stored in the COMPUTED QUANTITIES TABLES (COMQ) and updated every 5 seconds; they can be displayed whenever requested by the user.

Finally TEST CONTROL is called to control the sequence and duration of the work tasks requested by the user. If the current work task has reached its end and no other work task is scheduled, a TERMINATION subroutine is called; otherwise, the TRANSITION INITIALIZATION is called to compute physiological values for transition from the previous work task to the new work task.

Transition Operation

Transition is a variable period of time, lasting 1 minute minimum, in which the hardware flow valves and drive motors are adjusted to the physiological values of the new work task (fig. 5). TRANSITION INITIALIZATION (TRNINT), called by TEST CONTROL, is responsible for initiating the process through which transitional physiological values are computed. TRNINT uses SEGIN 1 and SEGIN 2 to convert the physiological values of the new work task into hardware positions. (See "Converting Operation.") The converted values, transmitted to a TRANSITION TABLE, will be considered the basic values from which a delta will be added or subtracted, depending on whether the new work task requires higher (for example, walk-to-run) or lower (for example, run-to-walk) physiological values.

The total duration of transition is subdivided by TRNINT into four transition segments: T0, T1, T2, and T3. In segment T0, equal to 5% of the total transition time, TRNINT uses the values for breathing rate, breathing depth, gas flows, and breathing waveform from the work task just completed; in transition segment T1, equal to 20% of the total transition time, TRNINT uses values of the preceding work task plus or minus 10% of the value of the new work task; in transition segment T2, equal to 70% of the total transition time, TRNINT uses values of the preceding work task plus or minus 90% of the value of the new work task; finally, in transition segment T3, equal to 5% of the total transition time, TRNINT uses values of the new work task. TRANSITION CONTROL, called by TRNINT, controls the sequence and duration of these transition segments; it also transmits the transitional values to ACTAB at the proper time. INITIAL CONTROL, called by TEST CONTROL at the beginning of transition, positions and controls through the appropriate subroutines the propane and CO_2 valves and the fulcrum and bellows drive motors (FRC does not change during transition) to the expected transitional values spelled out in ACTAB. The control over the bellows, during transition, is exerted by the TRANSITION CONTROL subroutine.

At the end of transition segment T_3, the software program, through the TRANSITION CONTROL, calls SEGIN 1 and SEGIN 2 to begin the converting process of programed physiological values for the next work task.

SUMMARY

This report has presented the Automated Breathing Metabolic Simulator (ABMS) and its hardware and software systems. Special emphasis has been given to the method by which the software program subroutines control the hardware mechanisms during the simulation of man's respiratory and metabolic functions.

The ABMS, consisting of a bellows, an oxidation chamber, and a temperature and humidity conditioner, simulates man's physiological functions during a sequence of work tasks, allowing the researcher to examine breathing apparatus under controlled test conditions. For each work task, the breathing rate, breathing depth, energy expenditure, functional residual capacity, and breathing waveform, which values have been previously programed in the STANDARD STATES TABLES, may be simulated.

Man's breathing functions are simulated by the bellows while drawing air from the respiratory device and pumping expired air into the device. The motion of the bellows, accomplished by a drive motor, simulates the breathing rate; the breathing depth is controlled by a fulcrum drive motor.

Man's metabolism is simulated by controlling the CO_2-to-O_2 ratio in the expired air. This is accomplished by drawing inspired air into the oxidation chamber, where propane is added to burn the oxygen and to produce carbon dioxide. An additional amount of CO_2, varying with the work task, is added to the chamber to obtain the correct metabolic ratio. The propane and CO_2 flows are controlled by metering valves. The air mixture is passed to a temperature-humidity conditioner, where it is conditioned to 100% humidity. The hardware mechanisms that are responsible for the simulation are thus the three drive motors, bellows, fulcrum, and FRC, and the propane and CO_2 flowmetering valves.

The software program through its assembly language subroutines exerts three main operations during the simulation processes:

1. It converts the respiratory and metabolic parameter values into hardware mechanism positions.

2. It positions, controls, and monitors the position of those hardware components.

3. It controls the transition from one work task to a new work task.

The TEST PREPARATION is responsible for initiating most of the processes by calling the appropriate subroutines to perform their functions, as described in the following paragraphs.

The converting operation is performed by SEGMENT INITIALIZATION 1 (SEGIN 1) and SEGMENT INITIALIZATION 2 (SEGIN 2) in the following way: SEGIN 1 converts the breathing waveform data for a given work task into bellows positions, transmitting the values to the BELLOWS REFERENCE TABLES. SEGIN 2 converts the energy expenditure (British thermal units per hour) into O_2 consumption (the propane and CO_2 flows will be derived from this value),

converts the breathing rate into bellows drive motor voltages, and converts the breathing depth and FRC values into fulcrum positions, transmitting the values to the ACTIVE SEGMENT TABLES (ACTAB).

The positioning operation is accomplished by the INITIAL CONTROL, which through the PROPANE, O_2 DEPTH-FULCRUM, WAVE-DRIVE, and FRC control subroutines, positions the propane and CO_2 flow valves and the bellows, fulcrum, and FRC drive motors, according to the values reported in ACTAB. These controlling subroutines also set up a comparison process between the values reported in ACTAB and the values transmitted by the ABMS, as the simulation progresses.

The transition operation is accomplished by the TRANSITION INITIALIZATION (TRNINT). TRNINT uses SEGIN 1 and SEGIN 2 to compute the transitional values from one work task to another. The transitional period is subdivided into four transition segments, of variable time duration, during which the hardware flow valves and drive motors are adjusted to the physiological values of the new work task. At the end of the transition time, SEGIN 1 and SEGIN 2 are called to begin the converting process for the next work task.

APPENDIX.--COMPUTER PROGRAM SUBROUTINES FOR ABMS

Command Processing

CONSTITUENT SUBROUTINES		FUNCTIONS
INITIATE COMMAND	(INCMD)	Performs the requested action. The most important command is the INITIATE command, which handles test definition.
ALTER COMMAND	(ALTCMD)	
START UP COMMAND	(STPCMD)	
STAND BY COMMAND	(STYCMD)	
IDLE COMMAND	(IDLCMD)	

TEST INITIATION

TEST PREPARATION	(TSTPRP)	Uses the information supplied via the INITIATE command to set up test conditions.
START TEST	(STEST)	

DRIVES CONTROL

INITIAL CONTROL	(INCNTL)	Adjusts control in breathing simulator, which affects propane and CO_2 consumption, fulcrum position, and FRC. Used at work task initiation and continuously during transition between segments.
PROPANE CONTROL	(PROCNT)	
CO2 CONTROL	(CO2CNT)	
FUNCT. RESID. CAP.	(FRCNT)	
FULCRUM CONTROL	(FULCNT)	

TEST SEQUENCING

SEGMENT INITIALIZATION 1, 2	(SEGIN 1, 2)	Handles work tasks termination and initiation, causes output requested by the user to be produced on schedule, and detects end of test.
BELLOWS REF. TABLE	(REFSTR)	
DETERMINANT EVALUATION	(DETVAL)	
BELLOWS DRIVE VELOCITY CONVERS.	(WAVDR)	
DEPTH FULCRUM POSITION	(DEPSTR)	
GASFLOW	(GASFLW)	
TEST CONTROL	(TSTCNT)	

Transition Sequencing

CONSTITUENT SUBROUTINES		FUNCTIONS
TRANSITION INITIALIZATION	(TRNINT)	Handles simulator control during work task to work task transition. It controls the duration of each transition segment, and initiates parameter adjustment during the transition.
TRANSITION CONTROL	(TRNCTL)	

BELLOWS SEQUENCING

TRANSITION BELLOWS CONTROL	(TRBLCT)	Maintains the bellows parameters to conform with the desired breathing waveform.
BELLOWS CONTROL	(BELCTL)	

TEST MONITORING

TEST MONITOR	(TSTMNT)	Monitors the state of the breathing simulator, watching for abnormal conditions which require the test to be prematurely terminated. Recomputes output values from simulator, which are periodically displayed by the output control process.
CHECK	(CHECK)	
READ INPUT ANALOG/DISCRETES	(RIAD)	
OUTPUT PARAMETER CALCULATION	(OPCAL)	

Keyboard Service

CONSTITUENT SUBROUTINES		FUNCTIONS
KEYBOARD INTERRUPT HANDLER	(KIH)	Assembles a line of input from the keyboard, and invokes the appropriate command processor.
OUTPUT CONTROL		
OUTPUT PROCESSORS INITIALIZER	(OUTPI)	Schedules output requested by the user, on both printer and punch.
PRIORITY PRINT PROCESSOR	(PRPR)	
PUNCH PARAMETERS PROCESSOR	(PURP)	
PRINTER CONTROL		
PRINTER PARAMETERS PROCESSOR	(PRTP)	Outputs information to teleprinter, including both parameter values and incidental messages.
PRINT SUB.	(PRTSUB)	
PRINTER INTERRUPT HANDLER	(PIH)	
PLOT WAVEFORM	(PLOT)	
WAVE DATA OUTPUT	(WAVDAT)	
COLLECT SAMPLES	(COLSAM)	
GRAPH-WAVE INITIALIZER	(GWINT)	
PUNCH CONTROL		
PUNCH PARAMETERS PROCESSOR	(PUNP)	Outputs parameter values requested by the user on the paper tape punch.
PUNCH SUB.	(PUNSUB)	
PUNCH	(PHS)	
PUNCH INTERRUPT HANDLER	(PUNIH)	

Bellows Monitoring

CONSTITUENTS SUBROUTINES	FUNCTIONS
INDEX TIMEOUT (IXTOUT)	Monitors the bellows to insure continuing operation. Terminates test upon bellows failure.
TERMINATION	
TERMINATE TEST (TRMATE) INITIALIZER (INITZ)	Terminates test, and shuts down breathing simulator if requested.
TIMER CONTROL	
TIMER TABLE QUEVE (TTQ) TIMER INTERRUPT HANDLER (TIH)	Controls scheduling of processes that request delays in their execution.
TIME UPDATE	
TIME UPDATE PROCESSOR (TIMPRO)	Maintains time of day.
MESSAGE OUTPUT	
MESSAGE HANDLER (MSGHDL) ERROR MESSAGE (ERMSG) TIME OF DAY OUTPUT (TODOUT)	Converts and outputs error messages to the teleprinter.

Conversion

CONSTITUENT SUBROUTINES		FUNCTIONS
LEGAL ASCII PRINT	(LAP)	Handles numeric conversion between binary and several external formats.
ASCII FIXED POINT TO BINARY	(AFPTB)	
BINARY TO ASCII FIXED POINT	(BTAFP)	
BINARY TO ASCII INTEGER	(BTAI)	
ASCII OCTAL TO OCTAL	(AOTO)	
ASCII INTEGER TO BINARY	(AITB)	
OCTAL TO ASCII OCTAL	(OTAO)	

SCHEDULER

PRIORITY PROCESSOR (PRPROC)	Handles execution control of processes awaiting execution. Works closely with Timer Control.

SCALING/DOUBLE PRECISION

DYNAMIC SCALE	(DSCALE)	Performs extended accuracy arithmetic as required mostly by Test Initiation.
DYNAMIC SCALED MULTIPLY/DIVIDE	(DSMPY/DSDIV)	
DYNAMIC SCALED ADD/SUBTRACT	(DSADD/DSSUB)	

SAVE AND RESTORE

SAVE REGISTERS	(SVREG)	Handles register saving and restoring actions.
RESTORE REGISTERS	(RSREG)	
SAVE SPECIAL REGISTERS	(SVSP)	
RESTORE SPECIAL REGISTERS	(RSSP)	

MISCELLANEA

TERMINATION CHECK	(TERM)	Miscellaneous subroutines, mostly with scanning functions, used by command processing.
LOGICAL SHIFT	(LGSH)	
SEARTH FOR FIELD	(SFLD)	
CALL AFPTB	(CAFPTB)	
CALL AITB	(CAITB)	
SKIP SPACES	(SKSP)	

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